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(54) Watthour meter with integrated self-testing

(57) To perform the self-testing of a watthour meter, an electric work Wl done on a load and a testing electric work Wt done on a first and a second resistor (R1, R2) of a voltage divider in a voltage sensor (1) are measured. To measure the electric work Wl, controlling output signals of a digital signal processor (8) close a first controlled switch (s1) and a third controlled switch (s3) in their first half-period T/2 and close a second controlled switch (s2) and a fourth controlled switch (s4) in their second half-period T/2, whereat the controlled switches (s1, s2, s3, s4) connect the outputs of both sensors (1, 2) one with another and to the mass. To measure the testing electric work Wt, the digital signal processor (8) reverses the polarity of test signals synchronously with the said switching of the controlled switches (s1, s2, s3, s4).

The testing of the watthour meter of the invention proceeds automatically on the metering position and the result may be noticed each time when reading the watthour meter or remotely at any time.

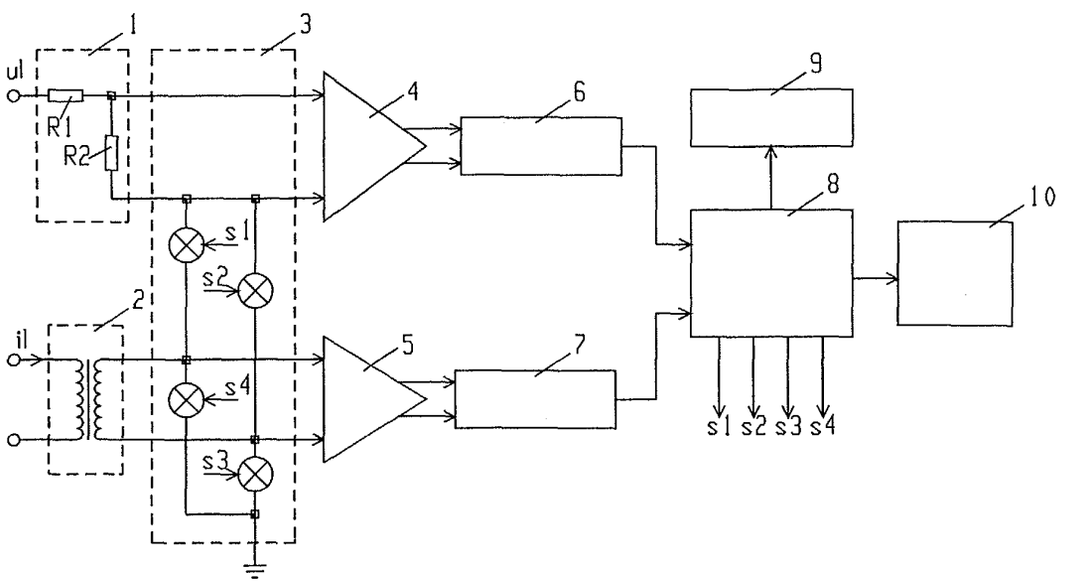

Fig.1

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Description

[0001] The invention concerns a watthour meter, which is provided with a voltage sensor in the form of a voltage divider and with an inductive current sensor sensing a current flowing through a load, the output signals of said sensors being amplified and digitized, and with a digital signal processor, which according to the invention generates signals to control a switching matrix so that, in order to perform a self-testing of the watthour-meter operation, an electric work Wl on the load and a testing electric work Wt done on the resistors of said voltage divider are measured alternatingly.

[0002] A watthour meter has an operating life usually exceeding twenty years and it must operate reliably and precisely through this whole period. The testing of its correct operation is performed in a laboratory. The transport of the watthour-meter to the laboratory is expensive and may even prove unnecessary if the watthour meter operates correctly. These expenses could be avoided if the watthour meter could test itself when operating, since only those watthour meters, at which a maloperation or a failure was ascertained by means of the self-testing, would be tested in the laboratory.

[0003] Consequently, the technical problem to be solved by the present invention is to furnish a watthour meter of said kind in such a way that it will be able to test the operation of all its elements including voltage sensor and the current sensor by itself.

[0004] According to the invention the said technical problem is solved by a watthour meter of said kind, its feature according to the invention being comprised in the characterizing part of the first claim. The features of further embodiments of the invention are specified in dependent claims.

[0005] The invention will now be explained in more detail by way of the description of embodiments and with reference to the accompanying drawing representing in:

Fig. 1 the watthour meter of the invention and
Fig. 2a and b graphs representing the time dependence of the electric work in two circuit arrengements during the watthour-meter self-testing.

[0006] A watthour meter is provided with a voltage sensor 1 sensing the mains voltage ul that is *i.e.* the voltage across a load, and with an inductive current sensor 2 sensing a current il flowing through the load. The output signals of said sensors 1, 2 are amplified in an amplifier 4 and 5, respectively, and then digitized in a Σ-Δ analog-to-digital converter 6 and 7, respectively. Their output signals are processed in a digital signal processor 8 (Fig. 1). The processing of the measuring signals in the watthour meter is performed in any known way, for example according to the technical teaching in the patent application SI 200200216 (EP 1 378 756 A2) by the present applicant.

[0007] The voltage sensor 1 is made as a voltage divider consisting of a first resistor R1 and a second resistor R2.

[0008] The sensor 2 sensing the current flowing through the load is preferably an inductive current sensor, however, if a different current sensor is used, it is furnished with an added coil.

[0009] A switching matrix 3 assembled of four controlled switches s1, s2, s3 and s4 is connected to the output terminals of the voltage sensor 1 and of the current sensor 2.

[0010] The first controlled switch s1 is connected between the second output terminal of the voltage sensor 1 and the first output terminal of the current sensor 2. The second output terminal of the voltage sensor 1 is here specified as follows: in the watthour meter performing only the measurent of the electric work Wl done on the load without performing also the self-testing of the watthour meter, the second output terminal of the voltage sensor 1 is mass-connected; this can be achieved by closing the controlled switches s2 and s3.

[0011] The second controlled switch s2 is connected between the second output terminal of the voltage sensor 1 and the second output terminal of the current sensor 2. The third controlled switch s3 is connected between the second output terminal of the current sensor 2 and the mass, and the fourth controlled switch s4 is connected between the first output terminal of the current sensor 2 and the mass.

[0012] The electric work Wl done on the load and a testing electric work Wt done on the first and second resistor R1 and R2, respectively, of said voltage divider in the voltage sensor 1 are measured in order to perform the self-testing of the watthour meter when it is in operation. The testing electric work Wt results from an excitation by means of a measuring signal, which is known, and the response to this signal is known as well.

[0013] To measure the electric work Wl done on the load, the controlling output signals of the digital signal processor 8 close the first controlled switch s1 and the third controlled switch s3 in their first half-period T/2 and close the second controlled switch s2 and the fourth controlled switch s4 in their second half-period T/2. When the first controlled switch s1 and the third controlled switch s3 are closed, across a secondary coil of the current sensor 2, there is induced an additional voltage which results from a current dictated by the mains voltage ul across the resistor chain R1+R2 of the voltage divider in the voltage sensor 1.

[0014] To measure the testing electric work Wt done on the resistors R1, R2 of the voltage divider, the digital signal processor 8 reverses the polarity of test signals synchronously with said switching of the four controlled switches s1,

s2, s3, s4.

[0015] The electric works Wl and Wt are specified as:

$$Wl = \frac{R1}{R2} * ul * il * K, \quad (1)$$

$$Wt = \frac{R1}{R2} * ul * \frac{ul}{R1+R2} * K, \quad (2)$$

where K is a watthour-meter constant. Its value determines the precision of the watthour meter and this value is tested in the self-testing procedure.

[0016] Of course, it is supposed that the mains voltage ul is equal in all network and hence known. Thus in the equations (1) and (2) il and K are unknown quantities. The digital signal processor 8 namely calculates the electric work Wl done on the load and the testing electric work Wt done on the resistors R1, R2 of the voltage divider in the voltage sensor 1 as it is also graphically shown in Figs. 2a and 2b, on the basis of said measurements during self-testing of the watt-hour meter from the following equations

$$Wl = \frac{1}{2N}\sum_{i=1}^{N}(Wl_i + (-1)^i Wt_i), \quad (3)$$

$$Wt = \frac{1}{2N}\sum_{i=1}^{N}(Wt_i + (-1)^i Wl_i). \quad (4)$$

[0017] In the equations (3) and (4), 2N represents the number of half-periods; an individual addend is related to the i^{th} half-period.

[0018] If the electric work Wl done on the load varies within the measuring period T, the measurement is performed until the current value of said electric work Wl equals its value at the beginning of the measurement.

[0019] A deviation of the established value of the constant K of the watthour meter from a predetermined value indicates a failure of the watthour meter or an unprecise metering. This is either signalized in the display 9 on the watthour meter front plate, thus warning reader of the meter count, or it is communicated to a control station by means of a modem 10.

[0020] The testing of the watthour meter of the invention proceeds automatically on the metering position and the result may be noticed each time when reading the watthour meter or remotely at any time.

Claims

1. Watthour meter, provided with a voltage sensor (1) in the form of a voltage divider, consisting of a first resistor (R1) and a second resistor (R2), and with an inductive current sensor (2) sensing a current flowing through a load, the output signals of said sensors (1, 2) being amplified and digitized, and with a digital signal processor (8),
characterized in
that, in order to perform a self-testing of the watthour meter,
a first controlled switch (s1), connected between a second output terminal of the voltage sensor (1) and a first output terminal of the current sensor (2), said second output terminal of the voltage sensor (1) being mass-connected, when only the electric work Wl done on the load is measured without performing the watthour-meter self-testing, and
a second controlled switch (s2) connected between the second output terminal of the voltage sensor (1) and the second output terminal of the current sensor (2), and
a third controlled switch (s3) connected between the second output terminal of the current sensor (2) and the mass, and
a fourth controlled switch (s4) connected between the first output terminal of the current sensor (2) and the mass,

are controlled by output signals of the digital signal processor (8) in such a way
that in order to determine the electric work WI done on the load,
only the first controlled switch (s1) and the third controlled switch (s3) are closed in their first half-period of the control signals and
only the second controlled switch (s2) and the fourth controlled switch (s4) are closed in their second half-period of the control signals
and **that**, in order to determine a testing electric work Wt done on the resistors (R1, R2) of the voltage divider of the voltage sensor (1),
the digital signal processor (8) reverses the polarity of test signals synchronously with said switching of the four controlled switches (s1, s2, s3, s4),
and **that** the digital signal processor (8) calculates a watthour-meter constant K by means of the measured electric work WI done on the load and of the measured testing electric work Wt.

2. Watthour meter as recited in claim 1, **characterized in**
that, in the case that the electric work WI done on the load varies within the measuring period, the measurement is performed until the current value of said electric work WI equals its value at the beginning of the measurement.

3. Watthour meter as recited in any of previous claims, **characterized in**
that the output of the digital signal processor (8) is connected to a display (9).

4. Watthour meter as recited in claim 1, **characterized in**
that the output of the digital signal processor (8) is connected to a modem (10).

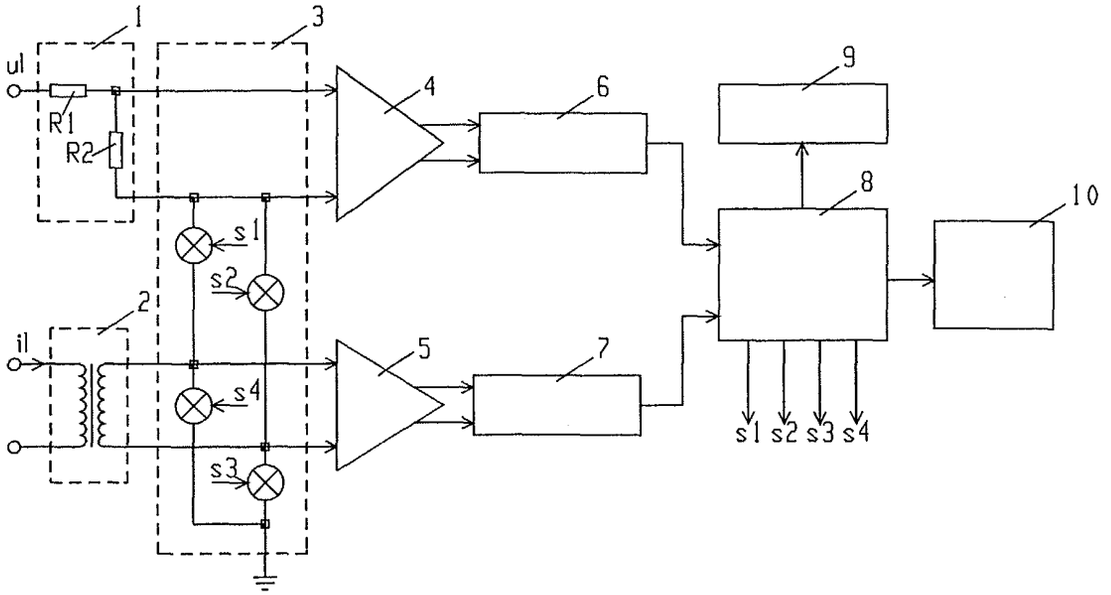

Fig.1

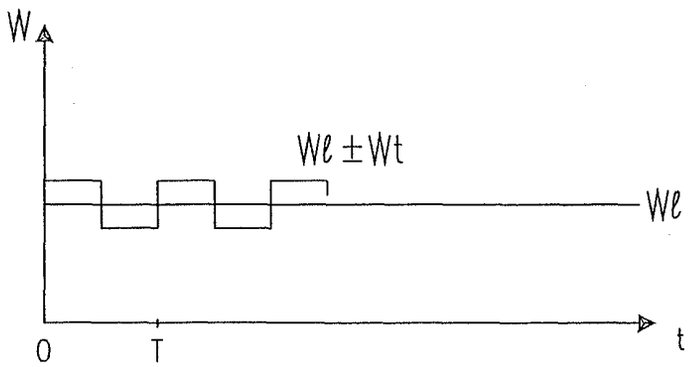

Fig.2a

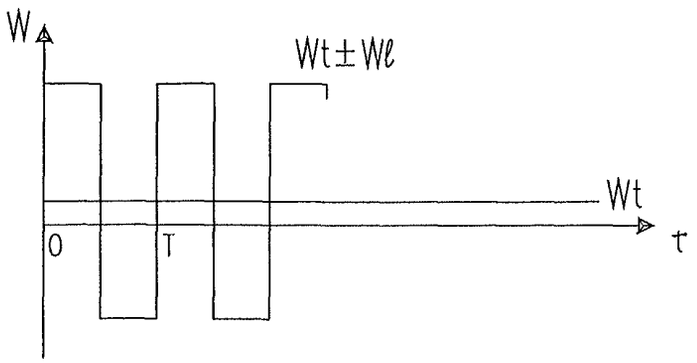

Fig.2b

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 46 8013

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A	EP 0 644 431 A (SILICON SYSTEMS INC ; GEN ELECTRIC (US)) 22 March 1995 (1995-03-22) * abstract; figures 25,3 * * page 6, line 17 - line 38 * * page 17, line 20 - page 18, line 16 *	1-4	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

G01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	8 November 2004	Ernst, M

CATEGORY OF CITED DOCUMENTS

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